

Science Education through Earth Observation for High Schools

Module 8: Ocean Currents

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UNIVERSITY OF SOUTHAMPTON AND
NATURAL ENVIRONMENT RESEARCH COUNCIL

**1st EARSeL Workshop on Education and Training
Istanbul, Turkey, 5-6 June 2008**

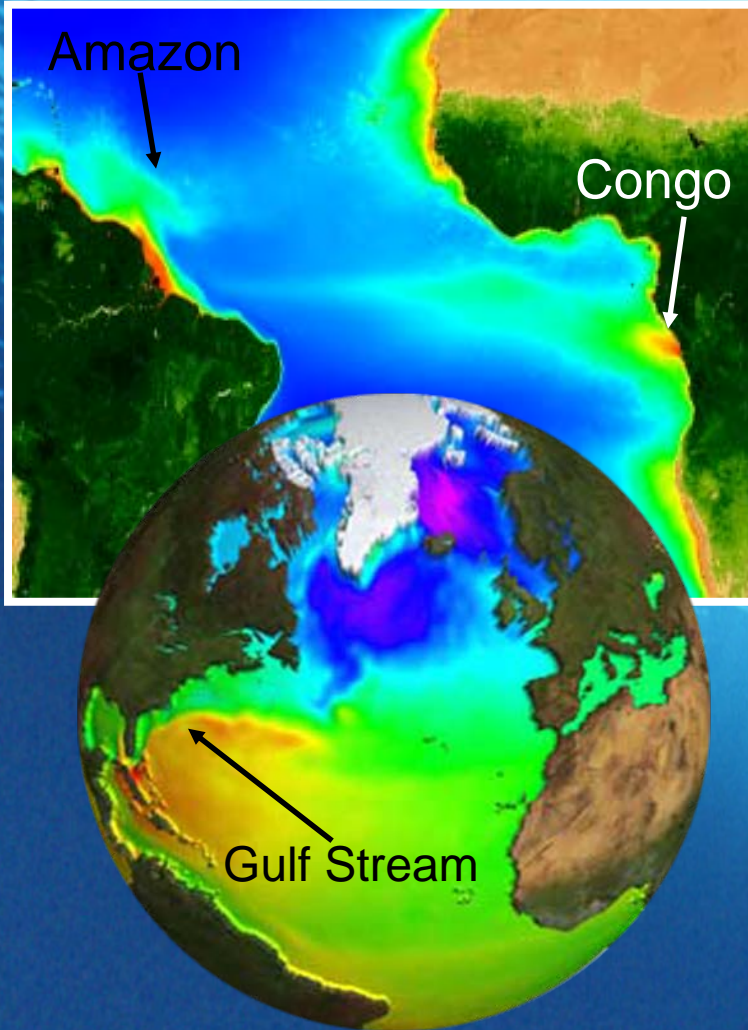
Ocean Currents

What are they and why should we care?

- Currents transport heat from equator to the poles
- Strong influence on climate
 - The Gulf Stream system warms northwest Europe
 - The California Current cools Hawaii
 - Water evaporates from warm currents and falls as rain over the eastern side of the main continents
- Important influence on marine life
 - And therefore on fisheries
- Impact on routing of marine traffic
- Electricity generation from tidal energy
- Transport of marine pollutants



Module overview



- What is an ocean current?
 - Rivers in the sea and how we measure them
- Wind driven surface currents
- The global conveyor
 - A planetary central heating system
- The thousand-year journey
- Tides and tidal currents
- Currents from space
- How currents affect us

Which of these are NOT used to measure ocean currents?



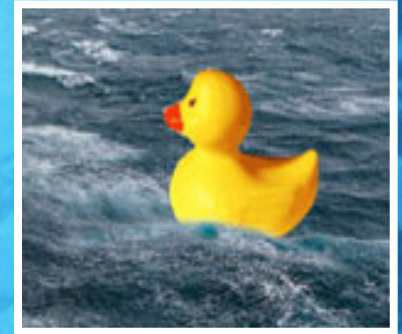
Nike trainer



Jason satellite



Speed gun



Plastic duck



Met buoy



Pressure recorder



ADCP



Argo float

Which of these are NOT used to measure ocean currents?



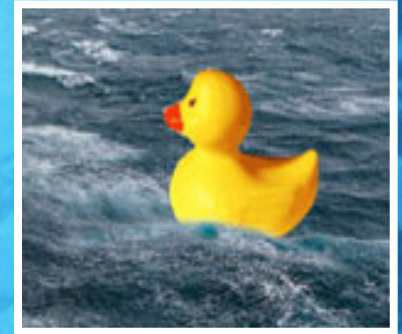
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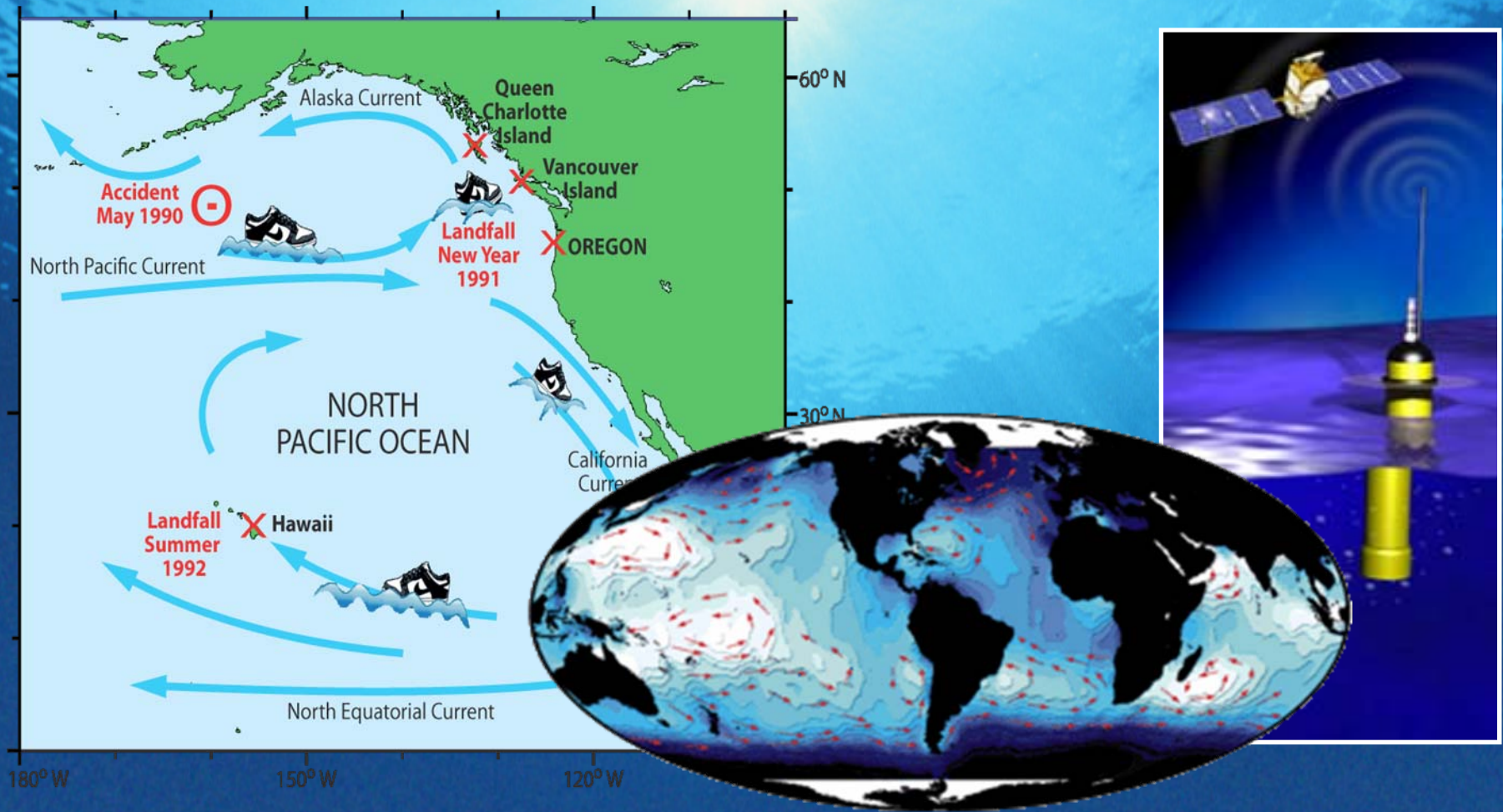
ADCP



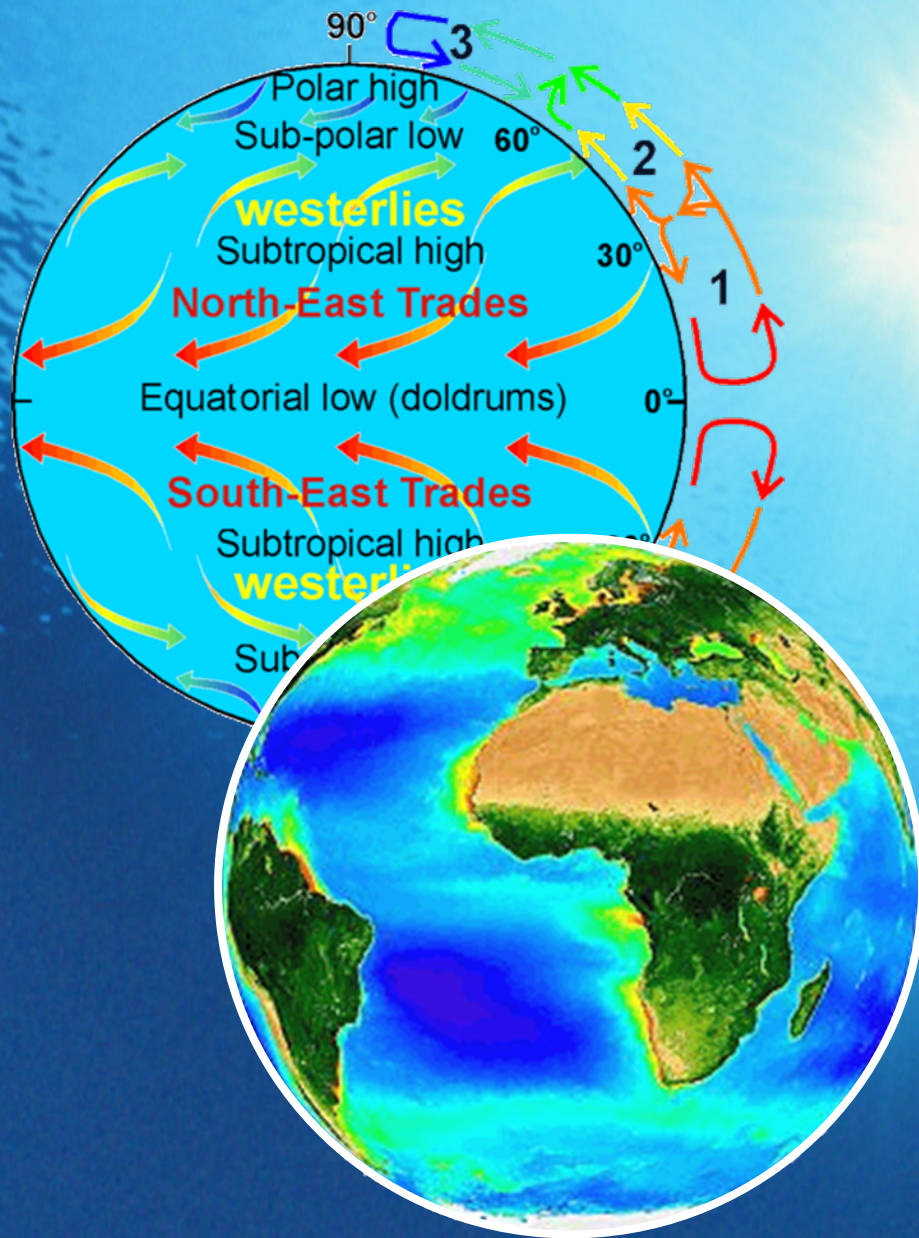
Argo float

Measuring Ocean Currents

From Nike trainers to Jason and the Argofloats



Wind driven surface currents



- Prevailing winds
 - how they are generated,
 - bands of prevailing winds
- Ocean surface currents
 - driven by prevailing winds
- Ocean gyres
 - formed by the main surface currents
- Ocean deserts
 - How the subtropical gyres affect ocean biology

Subtropical deserts - land and sea



Ocean Currents



Ocean deserts

Subtropical deserts - land and sea

From a biology point of view, the interiors of the large subtropical gyres are like ocean deserts, and they occur at about the same latitude as the large deserts on land.

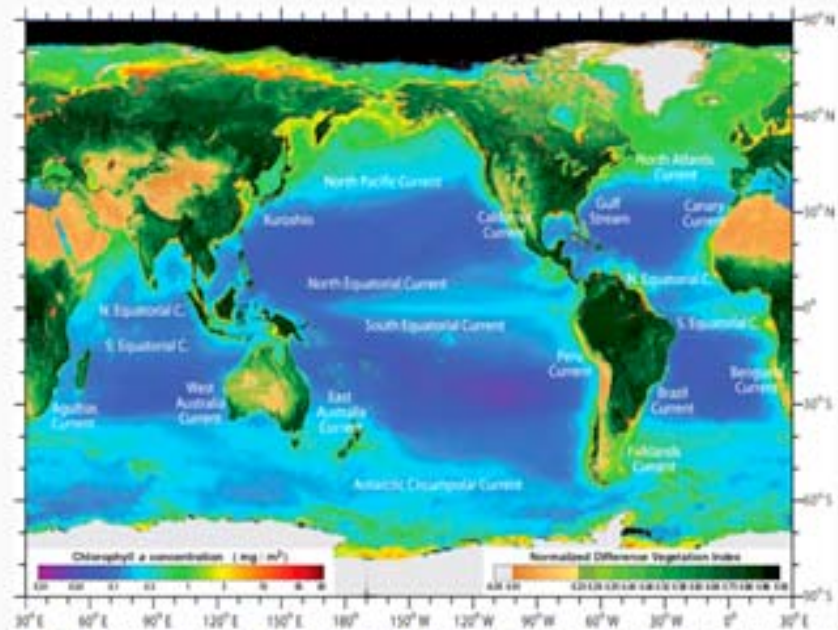
In the atmosphere semi-permanent subtropical high-pressure systems are centered at about 30 degrees latitude. They bring clear, dry air, with virtually cloud free skies, and little in the way of rain. The result is a subtropical desert so dry that they are unsuitable for all but the most specialised of plants, where rain falls only rarely - sometime less than once a year.

Possible in-depth: High and low pressure systems; ITCZ, link to large scale atmospheric circulation - link to previous page?

The ocean deserts are also caused by the subtropical high pressure systems, but result not from an absence of rain, but from a lack of plant nutrients in the surface waters brought about by solar heating, and an absence of strong winds.

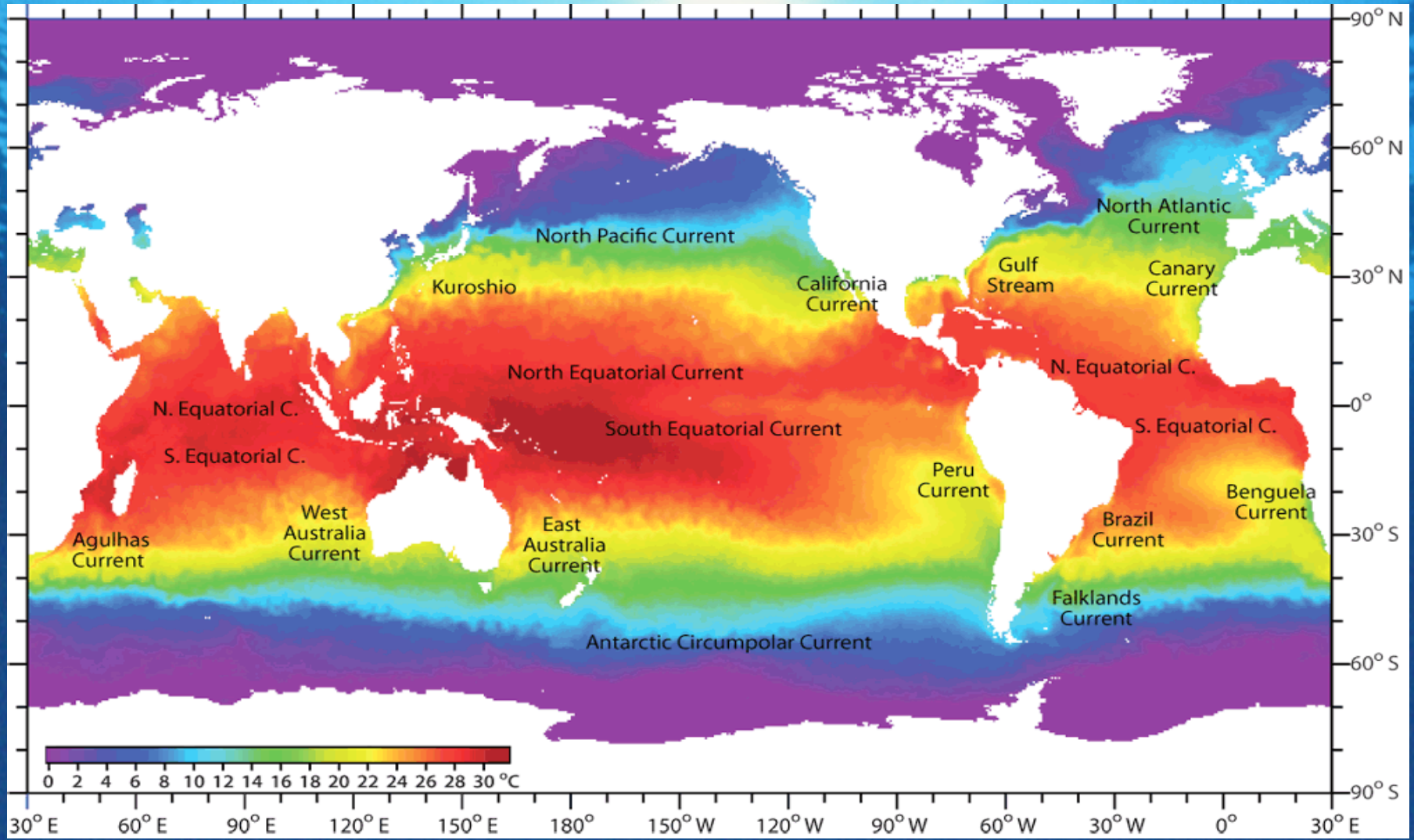
Microscopic marine plants

Near the surface water, microscopic marine plants - the phytoplankton - live in the sunlit zone, and carry out photosynthesis. The phytoplankton are the grass of the sea, and the bottom of the marine food-chain. Like all plants, however, they require not just water, carbon dioxide and light in order to grow, but also need nutrients such as nitrate, phosphate and other minerals.



Subtropical deserts. Map of ocean chlorophyll concentration (Chlor-a) and land vegetation index (NDVI) from NASA SeaWiFS data. This map shows the 10 year annual climatological chlorophyll from the SeaWiFS data set 1997-2007. Low productivity regions occur both in the ocean (purple) and on land (sand-colour), in subtropical high-pressure belt.

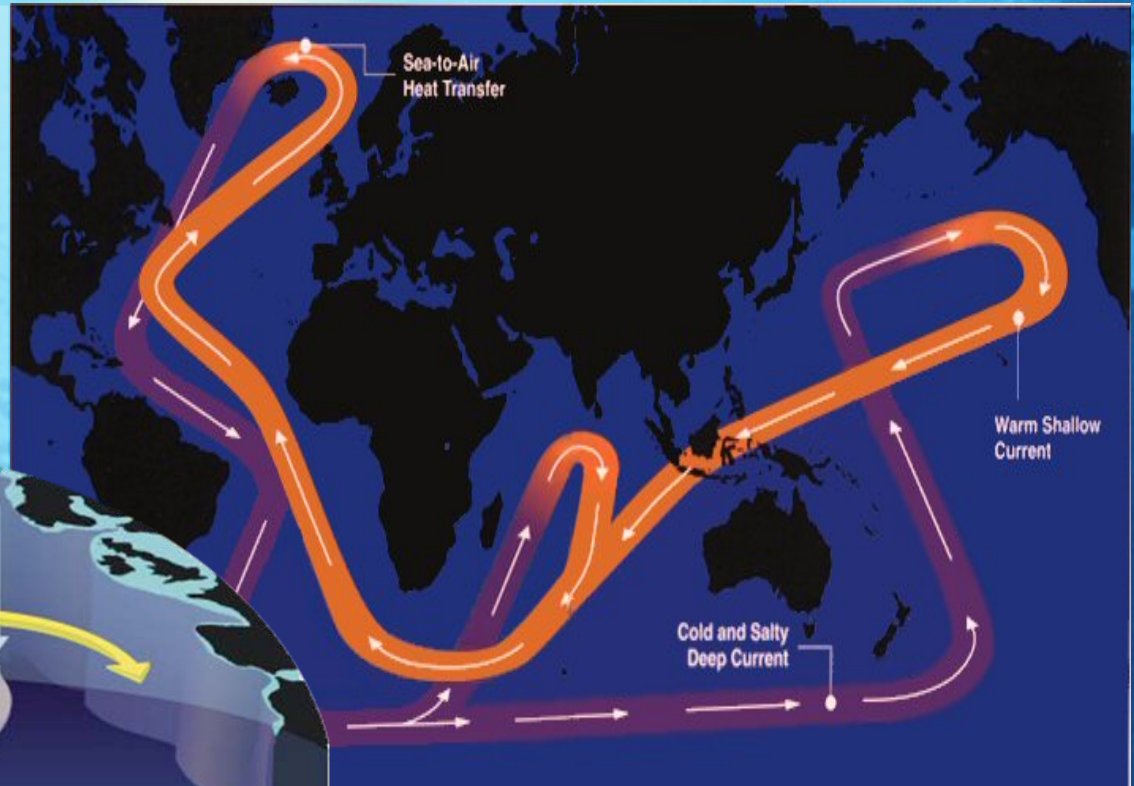
Surface currents and temperature



The global conveyor

An upside down planetary central heating system?

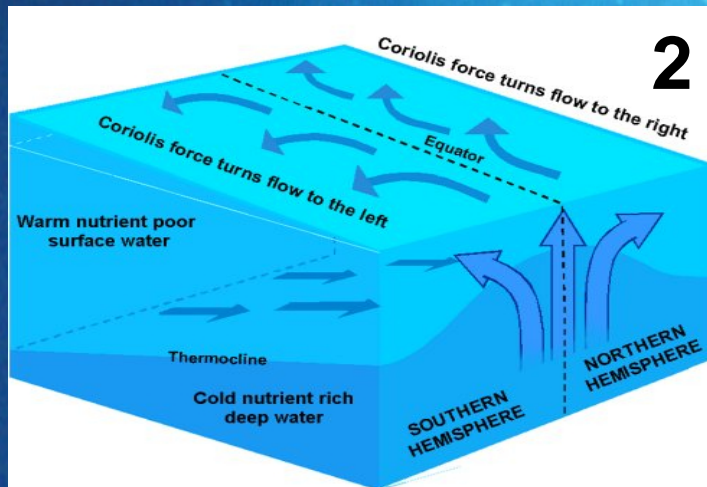
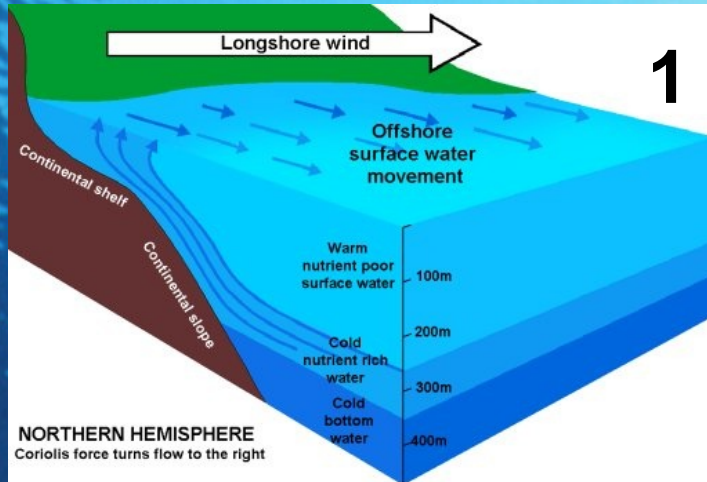
- Density, salinity and temperature
- Deep water formation
- Heat transport from equator to the poles



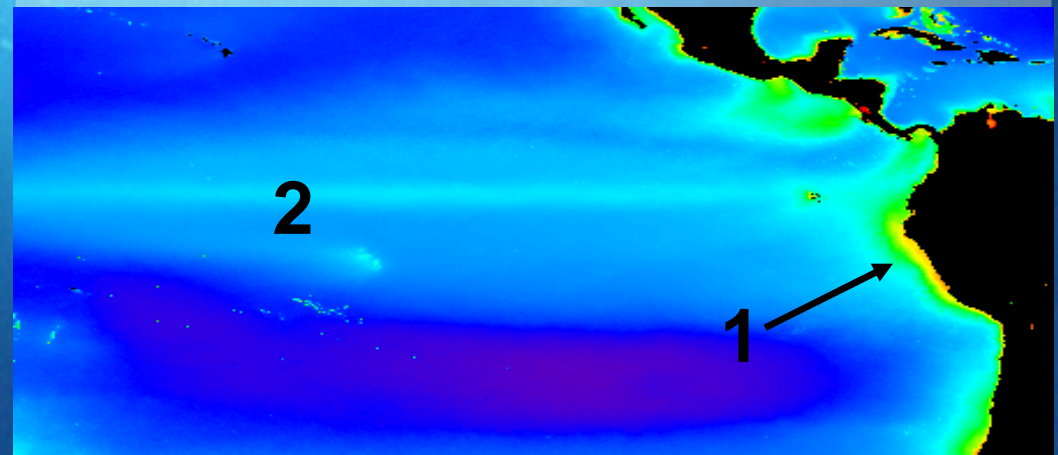
www.noc.soton.ac.uk/rapid/

The thousand-year journey

Can the deep ocean buy us time from global warming?



- $CO_{2\text{OCEAN}} = 50 \times CO_{2\text{ATMOS}}$
 - Most CO_2 in the deep ocean
- Transport to the deep: high latitude sinking and 'biological pump'
- Slow return to the surface
 - Mixing across thermocline
 - Coastal /equatorial upwelling



Tides and Tidal Currents

Introduction

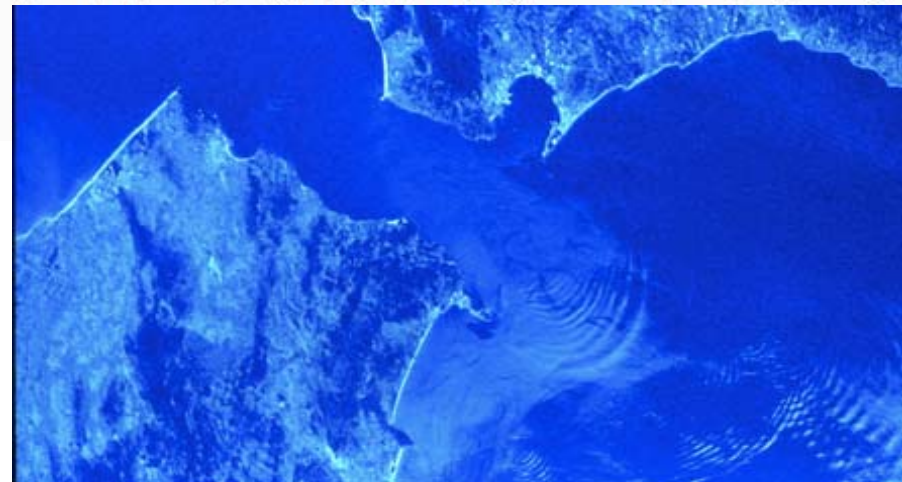
The wind and density driven currents we have covered in chapters 2 and 3 generally flow in the same direction all the time. The current strength may vary, perhaps with time of year, but currents such as the Gulf stream and the Kuroshio always flow in the same direction.

Where major currents change direction, it is usually just once or twice a year. In the Indian Ocean the North Equatorial Current reverses its direction in concert with the Indian Monsoon. From November to March, during the northeast monsoon, it flows westward, and during the rest of the year it flows eastward.

Tidal currents reverse once or twice a day.



Severn Bore
Source: http://www.bbc.co.uk/gloucestershire/focus/2005/03/severn_bore2.shtml Photo taken by Graham Bloomfield - March 12th 2005



Currents from space

The sea surface is not as flat as you may think



Ocean Currents



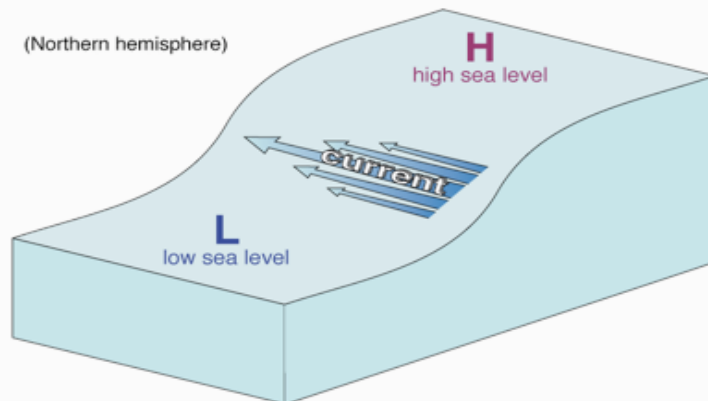
Currents from Space

Satellite altimetry

Radar altimeter

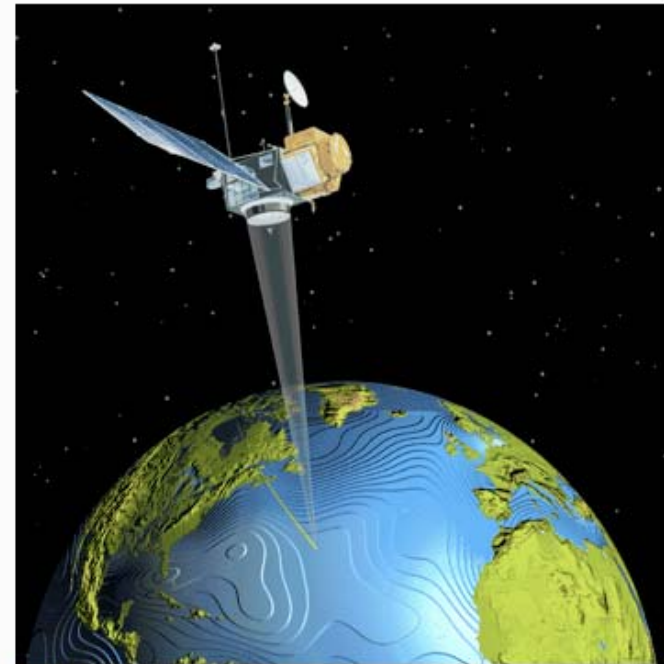
Altimeters have a parabolic antenna facing earthwards (see figure), and work by transmitting a pulse of microwaves towards the surface (just like any other radar), and measuring the time that the pulse takes to bounce back to the satellite. The longer the time, the longer the distance between satellite and sea surface.

Not as flat as you might think!



Here is the surface signature of large-scale currents. They flow where the sea level has a slope, and at a right angle to the slope due to the balance between pressure and Coriolis force

Too small too see?



Artist's view of the TOPEX/POSEIDON altimeter [Image by NASA]



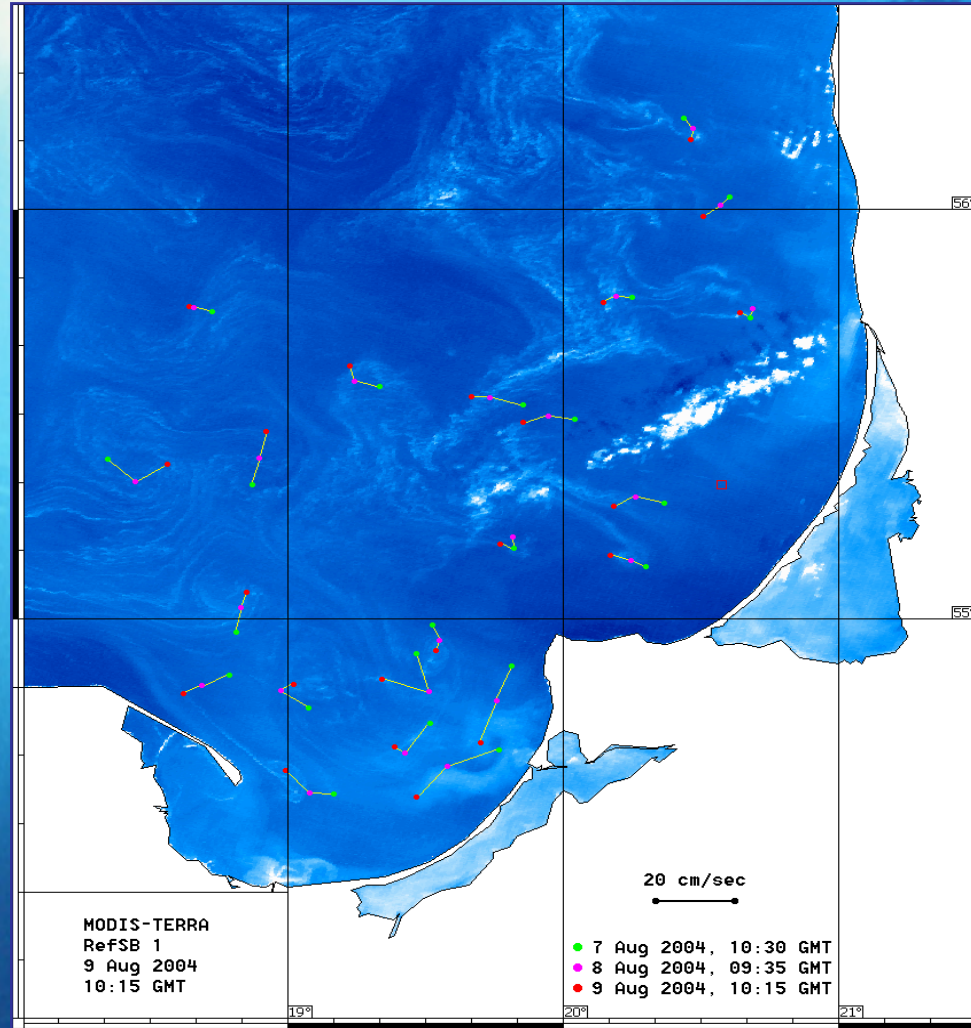
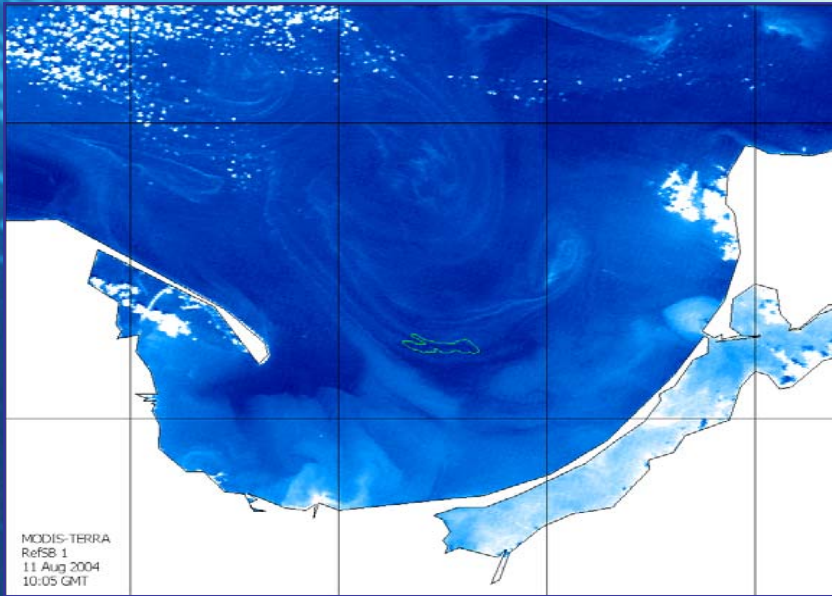
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Detecting currents using tracers

Suspended sediment reveals current eddies



Some UK Curriculum links

➤ Physics

- Scalars and vectors; rotational dynamics, circular motion; force, mass and acceleration; doppler effect.
- Assess the validity of physical information, experiments, inferences and statements.

➤ Mathematics

- Coordinate geometry, algebra and functions, trigonometry, sequences and series, simple algorithms
- Understand the relationship between real world problems and mathematical models Geography

➤ Biology

- Ecosystem dynamics, adaptation, energy flow, recycling.



Some UK Curriculum links

➤ Geography

- Climate: hazards and change, water resources; people and the environment;
- Physical geography; atmospheric system; hydrological systems;

➤ History

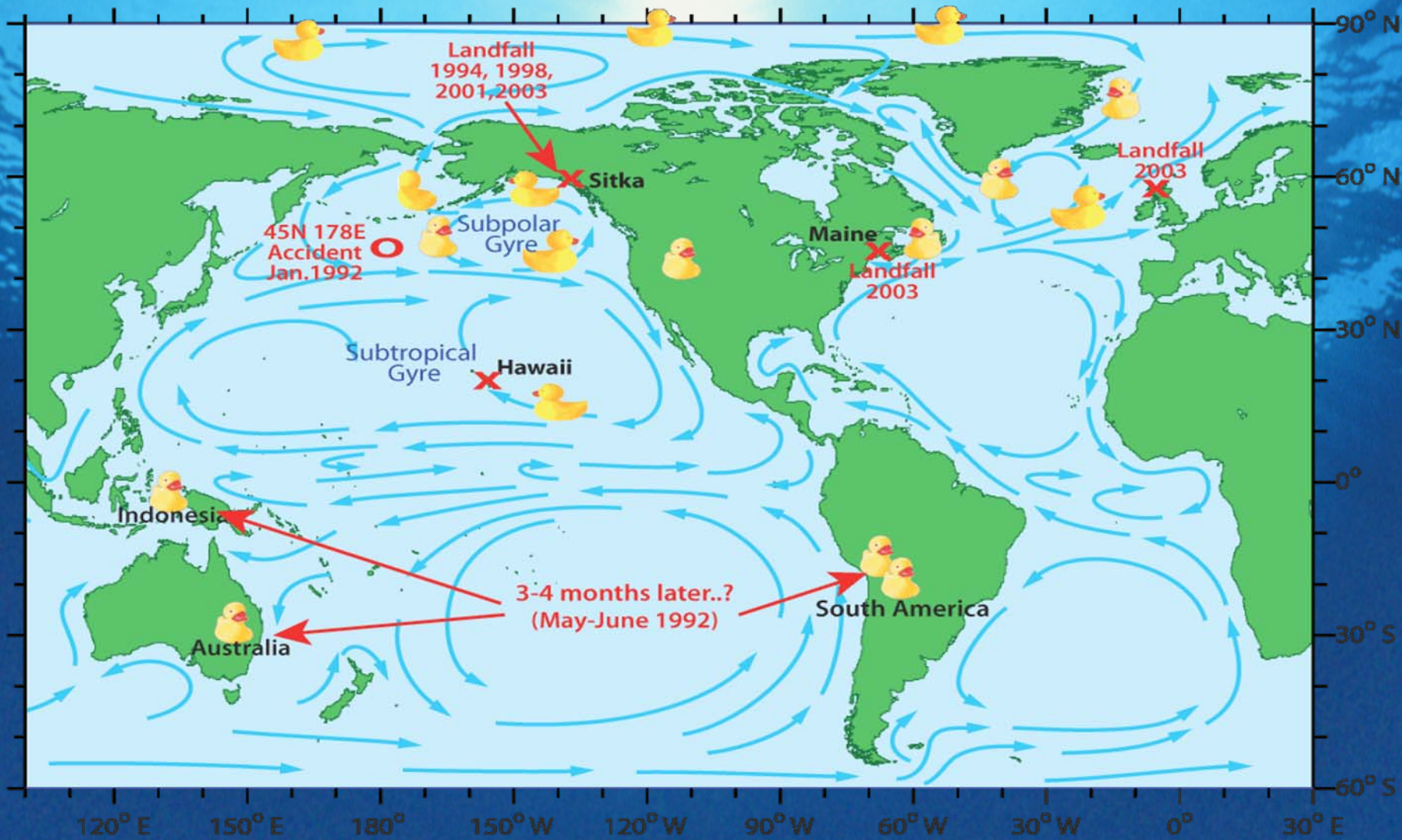
- Spread of Islam across the Indian Ocean; Kon-Tiki and migration across Pacific Islands; Franklin and the Gulf Stream

➤ English

- ?



Exercise: Fact or fiction?



Ocean currents - module summary

- Module still under construction
- First draft should be on-line for school testing in July
- Background information on ocean currents
 - What they are and how we measure them
 - Surface and deep currents
 - Currents and climate - including the global heat conveyor
 - Tides, tidal currents and tidal energy
 - Altimetry and other methods for measuring currents from space
- Exercises and games

THANK YOU



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